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NSREC Notes: Exhibitors Showcase Latest Reference Designs Along With Progress In Rad-Tolerant And Rad-Hard Power Components

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After two years of virtual conferencing, the Nuclear & Space Radiation Effects Conference (NSREC 2022) returned to in-person, holding its conference and exhibition July 18-22 in Provo, Utah. The industrial exhibits, which were held on Tuesday, July 19 and Wednesday July 20, hosted 49 exhibiting companies occupying a total of 55 (10-ft x 8-ft) booths with manufacturers of rad-hard power semiconductors and power modules well represented as usual. The conference registered 474 attendees for its technical sessions and given the level of activity in the exhibition, I would expect that most of these attendees visited the exhibits.

The power products on display in the NSREC 2022 exhibition were much in-line with those seen in recent years, either at the last in-person NSREC in 2019[1] or the two virtual editions[2,3] at which vendors gave online presentations as part of their virtual expo presence. Among the familiar power product sightings in this year's exhibition, power IC vendors continued to showcase their power management reference designs for the latest space-grade FPGAs from Xilinx and Microsemi. In some cases, these reference designs are offered with "flight-ready" development boards to ease system development.

And while power IC makers were busy the past few years introducing new power supply controllers and voltage regulators, at this year's NSREC, their news was more in the way of updates on the status of those previously introduced parts or parts still in development. Nevertheless, some IC and module suppliers did share information on new power supply controllers and point-of-load regulators (POLs). On the module side, some new isolated dc-dc converters, both single device/single stage and multi-device combinations were discussed with one established power module manufacturer making its debut at NSREC.

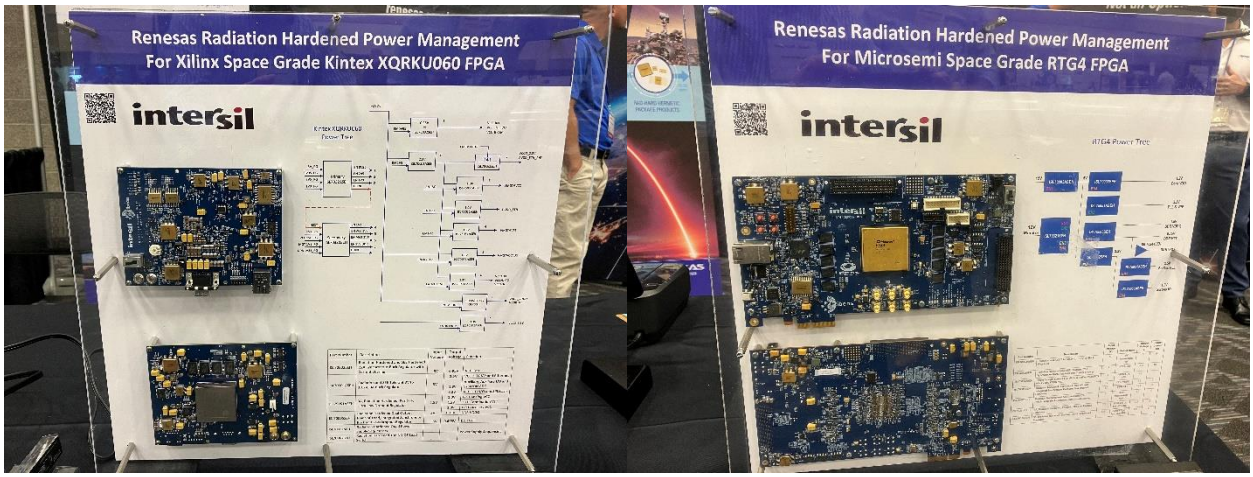
GaN devices were notable in a few of the exhibits, either for their use in application examples such as motor controllers, or in some recently introduced dc-dc converters. One vendor continues to expand its family of rad hard superjunction silicon MOSFETs with the introduction of p-channel devices and a new demo board for one of its gate drivers. On the packaging front, the development of space-grade parts in plastic packaging continues to progress, while some vendors also expand their offerings of hermetic packages to improve device performance and ease board assembly.

As in recent years, the trend of targeting "new space" applications with rad-tolerant components and reference designs continues. Nevertheless, the development of rad-hard power components and converters for MEO and GEO applications and other long-life, high-rel missions also goes on.

Powering Space-Grade FPGAs

At its booth, Renesas showed its rad-hard power management reference designs for two space-grade FPGAs—the Xilinix Kintex XQRKU060 FPGA and the Microsemi RTG4 FPGA, two radiation-tolerant devices. According to Kiran Bernard, product marketing specialist at Renesas Electronics America, these development platforms are as close to flight ready as possible (see Fig. 1). Although this is the first time these designs were shown at NSREC, they were first were discussed in May at the SEE/MAPLD Workshop in La Jolla.

The reference design board for the XQRKU060 was released in January or February, while the board for the Microsemi RTG4 FPGA was released last year. Looking ahead, there are other space-grade FPGAs coming from other vendors and according to Bernard, Renesas is developing reference designs for those devices too. Beyond that, he says the company plans to release a number of rad-hard power management ICs in Q4 of this year, and then one in Q1 and one in Q2 of next year.



(a) (b)

Fig. 1. Renesas's rad-hard power management reference designs for the Xilinix Kintex XQRKU060 FPGA (a) and the Microsemi RTG4 FPGA (b) include devices such as the ISL70321SEH power supply sequencer, ISL70001ASEH synchronous buck regulator, ISL75051ASEH LDO, the ISL770005SEH dual-output POL, sync buck and LDO and the ISL70062SEH load switch—among others.

Meanwhile, developments in the packaging area, particularly plastic packaging, continue. With respect to space products at Renesas, there are three product flows: rad-tolerant plastic (targeting LEO applications), rad-hard plastic with all the same qualifications as hermetic, and rad-hard hermetic.

According to Bernard, there's very little difference between rad-hard plastic and hermetic, except that rad-hard plastic sees more steps in qualification than hermetic because of details of plastic manufacturing. He also notes that there are very few outgassing concerns with rad-hard plastic, as outgas testing is performed on each plastic product.

Going forward, when Renesas introduces a component for space, they will try to release all three versions of the device (rad-tolerant plastic, rad-hard plastic and rad-hard hermetic) at once. However, the company will not quite be ready to do this on the power management parts that are expected later this year and early next.

At its booth, VPT showed members of the new VSC series of space COTS dc-dc converters that the company introduced during the week of NSREC. Similar to the company's VPT line of high-rel COTS converters, the series is designed for smaller satellites in low earth orbit (LEO), and NASA Class D missions where the balance of cost and guaranteed performance is critical. The VSC series is radiation tested to 42 MeV/mg/cm^2 and guaranteed to 30 MeV/mg/cm^2 for SEE and tested to 40 krad(Si) and guaranteed to 30 krad(Si) for TID (Fig. 2).

Fig. 2. Members of VSC series offer 5 W to 30 W of output power, including single and dual outputs of 3.3, 5, 12, and 15 V with a wide input range of 15 V to 50 V with 80-V transient capability.

The VSC series converters are available now. Additional information can be obtained by contacting a local VPT distributor.

VPT also showed its SGRB dc-dc converter, which was released about three years ago at the last in-person NSREC in 2019. This converter, which serves as one of the main supplies on a satellite, features 100-V input and 28-V output with share capability. It's also rad hard to 100 krad TID and 85 MeV/mg/cm^2.

According to Campbell Lowe, senior design engineer at VPT, sales of this converter have really started to take off. "It's a very popular product, and with some customers having it designed in on multiple programs, it could become its own new business for VPT," said Lowe.

IR HiRel, an Infineon Technologies company, displayed the rad-hard RIC74424 gate-driver eval board for the first time, following its release in June (Fig. 3). The RIC74424 driver IC itself was released a few years ago.

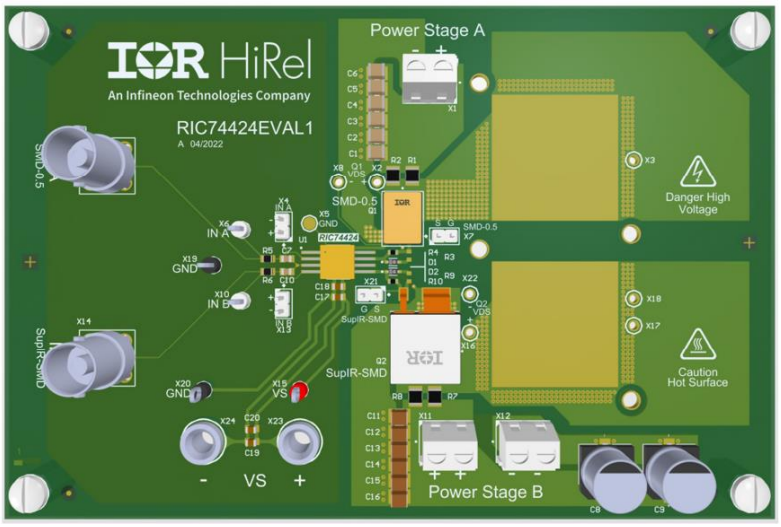


Fig. 3. This board is designed to help users evaluate the RIC74424 high-speed, dual-channel low-side gate driver in combination with any other rad-hard MOSFET in a SupIR-SMD, SMD-0.5 or SMD-0.5e package. It comes prepopulated with the 100-V IRHNJ9A7130 and 60-V IRHNS9A7064 n-channel MOSFETs.

According to Rushi Patel, applications engineer, discretes, at IR HiRel, in July the company released the IRHYS9A97034CM and IRHYB9A97034CM, which are 60-V, 46-mΩ R9 p-channel MOSFETs and planned to release a new member of the R9 rad hard MOSFET family in August, a 100-V, 47-mΩ p-channel MOSFET. All three devices are suitable for load switching and inrush current limiting applications. Information on the latest device, the IRHYS9A97130CM, is now available on the IR HiRel website.

Patel also noted that the company is planning to release an evaluation board for the R9 p-channel MOSFET (TO-257AA package) in the inrush current limiter application. "This is a common application in space power systems where a large bulk capacitance is present at input of a load such as intermediate bus converters (IBC)," said Patel.

This superjunction (SJ) device offers a significant step up in performance versus a comparable member of the company's R5 family of devices, which are planar-gate VDMOS devices. According to Patel, while the R5 planar p-channel MOSFET can handle 3.5 A at 28 V, the new R9 SJ p-channel MOSFET can carry 9.5 A at 28 V in linear-mode operation with the same size die and same package as the R5 model. At the same time, the R9 SJ p-channel MOSFET also has better electrical switching performance.

Additionally, the company displayed examples of two of its SMD packages—the SMD-0.5e and the SMD-0.2e. These devices, which replace their leaded equivalents—the SMD-0.5 and the SMD-0.2—mount directly to the board as opposed to upside down or "dead bug" style as the leaded parts are typically mounted. The direct mounting leads to better thermal performance. In addition, the new SMD packages eliminate the need for lead forming and manually soldering leads to the pc boards.[4]

According to Oscar Mansilla, the SMD-0.5e and the SMD-0.2e, leverage what the company learned from developing its SupIR-SMD package and the company will be releasing new MOSFET products in these packages at the end of the year. "We took what we learned from the SupIR-SMD in terms of material composition for the pads and applied similar materials in these new packages. This reduces the CTE mismatch and allows the direct-to-PCB mounting of these packages," says Mansilla.

However, unlike the SupIR-SMD, the SMD-0.5e and the SMD-0.2e have a ceramic body and lid. As a result, customers do not have to manually grind the lid to eliminate charge build-up in space. Customers now solder a wire from the SMD0.5/0.2 lid to PCB ground, said Mansilla.

While the SMD-0.5e and the SMD-0.2e are hermetic packages targeting the traditional high-rel, rad-hard space applications, the company is also aware of the demands for lower-cost components with lower radiation specs for "new space" applications and is looking into plastic packaging as another option.

Signaling its interest in new space applications, Vicor exhibited for the first time this year at NSREC. The company showed its three-chip solution for stepping down a 100-V bus to 3 V at 50 A. This power train also supports a three-chip 0.8 V at 150-A rail. This solution uses the company's BCM, PRM and VTM devices. The BCM is a 3:1 dc transformer using Vicor's patented Sine Amplitude Conversion (SAC) topology and isolation stage while the SAC VTM is an 8:1 divider, also a dc transformer. Meanwhile the PRM performs voltage regulation (Fig. 4).

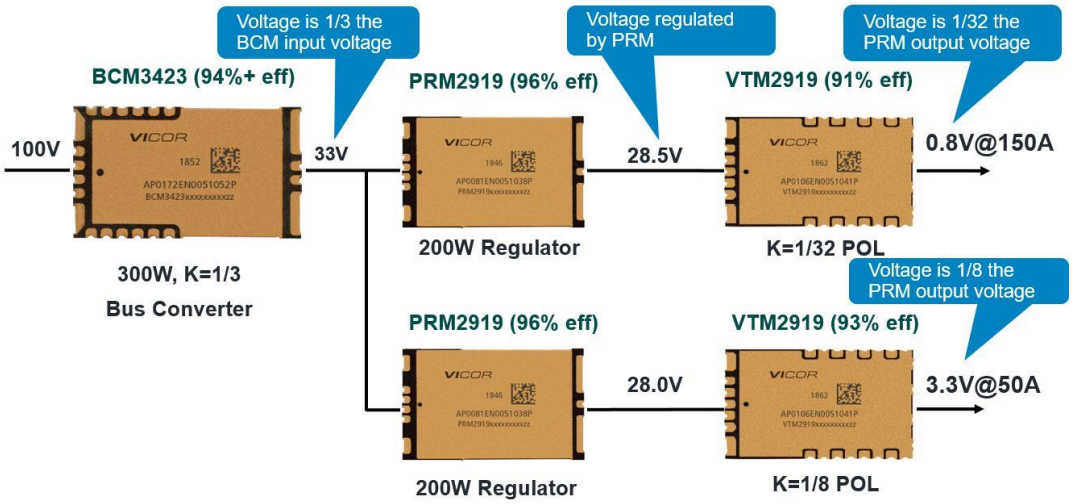


Fig. 4. Vicor's current rad-tolerant solution for powering ASICs includes the BCM, PRM and VTM devices shown here. The high efficiencies of the three devices are noted and are improved with the latest design. These converter chips (or CM-ChiPS in Vicor's packaging terminology) feature high power density. The BCM3423 delivers 300-W output in a 34-mm x 23-mm x 8-mm, 26-g package; while the PRM2919 outputs 200 W in a 29-mm x 19-mm x 8-mm, 16-g package and the VTM2919s produce 165 W with conversions ratios of 1/8 (for a nominal 3.3-V output) and 1/32 (for the nominal 0.8-V output) in a 29-mm x 19-mm x 5.5-mm, 13-g package.

Discussing the three-chip solution, Ken Coffman, senior field applications engineer at Vicor New Space Initiative, noted that within each module are 100% redundant power trains for SEE mitigation. Moreover, the modules are designed and tested to 50 krad with 50% margin (75 krad), and the company has pushed this to 80 krad to allow additional design margin for customers.

At its booth**,** EPC Space showed a reference design demo board for a rad-hard three-phase motor control plus driver with GaN FETs in the power stage (Fig. 5). This reference design (EPC7C006) was previously announced. However, the demo board just became available the week before NSREC.

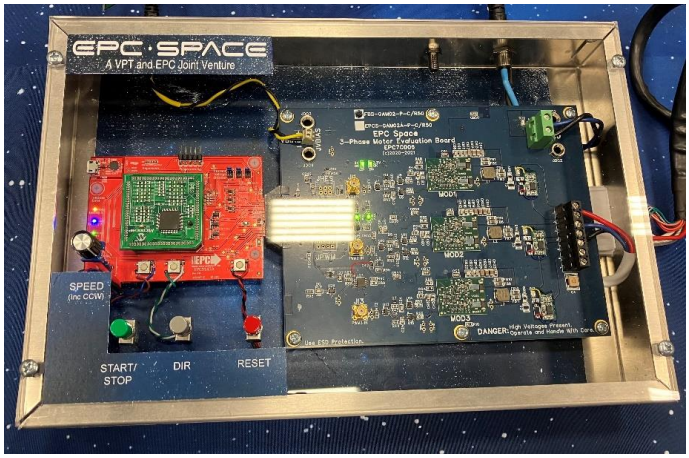


Fig. 5. The EPC7C006 demo board is a three-phase motor demonstration board measuring 6.50 in. x 5.22 in. that utilizes the FBS-GAM02-P-R50 as the phase control bipolar switches. The EPC7006 is designed to be either standalone, the phases driven by external PWM signals, or to interface with the EPC9147A microcontroller interface board (shown here on the left in red).

The GaN FETs used in this reference design are part of the EPC7xxx series, which was introduced last year. Unlike other commercial devices from EPC, these devices are designed for single event immunity at an LET of 85 MeV/mg/cm^2. The EPC7xxx parts exhibit only a 2% shift in $R_{DS(ON)}$ over 10 years and have full radiation hardening. EPC Space has plans for qualifying these devices per DLA's MIL-PRF-19500, starting in 2023 says Bel Lazar, CEO of EPC Space.

Although no specific GaN FETs were introduced at NSREC, there have been recent announcements like the EPC7018, a 100-V, 3.9-mΩ, 345-A pulsed, rad-hard eGaN FET in a small 13.9-mm^2 footprint, which was introduced in June (see the July issue of How2Power Today) and the EPC7007, a 200-V, 28-mΩ, 80-A pulsed, rad-hard eGaN FET in a 22-mm^2 footprint, which was announced the week of NSREC. Both devices are rated for a total dose immunity of 1000 krad and a SEE immunity for LET of 85 MeV/mg/cm^2.

In addition to its use in the previously mentioned reference design, EPC Space also displayed the FBS-GAM02-P-R50 motor drive module (see Fig. 6) in an example space application—a reaction wheel, which acts like a gyroscope. According to EPC Space, these modules and other GaN devices have been flying since 2017 with more than 100,000 GaN devices in orbit to date. The reaction wheel assembly on display was for a LEO application, but according to the company, they are also being flown in GEO satellites.

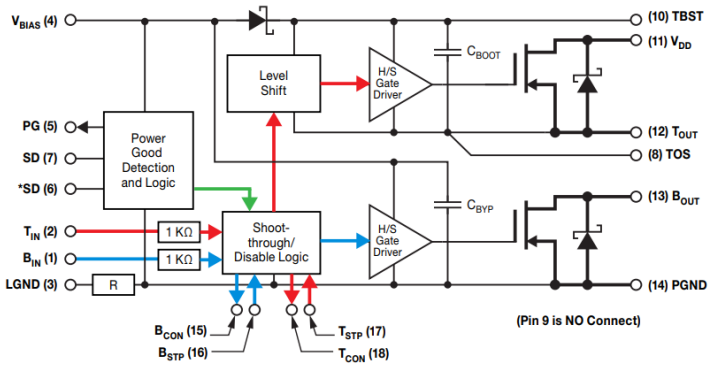


Fig. 6. The FBS-GAM02-P-R50 50-Vdc/10-A rad-hard multifunction power module. This module includes two output power switches, two high-speed gate-drive circuits (consisting entirely of eGaN switching elements), two power Schottky diode clamp elements with shoot-through prevention logic (for the half-bridge connection) and a +5-Vdc gate drive bias "power good" monitoring circuitry in a space-efficient, 18-pin SMT molded epoxy package.

Texas Instruments showed a development platform for the Versal space-grade (radiation-tolerant) FPGA from Xilinx. This development board was created by Alpha Data, whose expertise concerns the FPGA portion of the design. The space version of this board follows the Space VPX standard and features power at 12 V rather than 5 V for the intermediate bus (Fig. 7).

In this development platform, TI provides the whole power management solution for all the power rails required by Versal, an FPGA that consumes up to 150 A, which is considered high in the space world, according to Mark Toth, marketing & applications manager, Space Power Products at TI. TI's reference design includes the TPS7H4003-SEP, an 18-A 7-V input POL; the TPS7H4010-SEP, a 6-A 32-V input POL; and the TPS73801-SEP, a 1-A, 20-V input LDO. The reference design board shown by TI was the first rev of a brand new board that Alpha Data plans to start selling by the end of the year, and is based on radiation-tolerant plastic components from TI's Space Enhanced Plastic (Space EP) line.

Fig. 7. The Versal development platform for the Versal space-grade (radiation-tolerant) FPGA from Xilinx is described as a flight-ready board. Alpha Data plans to begin offering this board for sale by the end of the year.

Alpha Data also exhibited at this year's NSREC and was showing the same reference design board for the Versal FPGA at its booth. Commenting on this product, Adam Smith, CEO of Alpha Data, noted that this is a flight-ready board. Alpha Data, which is an Ecosystem Partner with Xilinx, also showed a reference design board for another space-grade FPGA, Xilinx's Kintex. This reference design board is about four years old, says Smith.

But coming back to the TI exhibit, the company also provided updates on its TPS7H5001-SP, a rad-hard PWM controller in a hermetic package, which was discussed last year at NSREC 2021. The TPS7H5001-SP is notable for its many features such as programmable deadtime and leading-edge blanking, which weren't available in the earlier space-grade controllers such as the UC1823 and UC1845. An eval board for the TPS7H5001-SP was on display at TI's booth (Fig. 8).

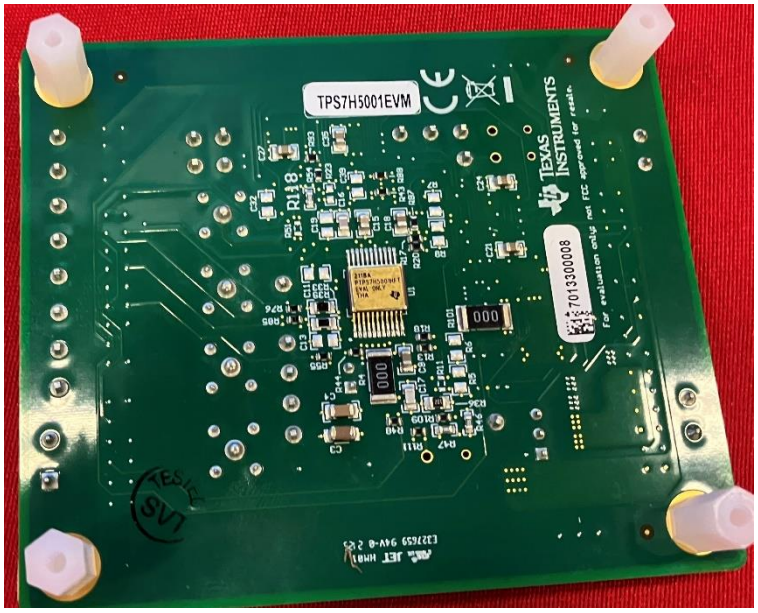


Fig. 8. An evaluation board for the TPS7H5001-SP PWM controller enables the controller to be connected to other components needed to quickly prototype and evaluate a complete power converter design. This EVM features synchronous rectification outputs with adjustable dead time; a 0.613-V voltage reference with ±1% tolerance over temperature, radiation, and line and load; adjustable slope compensation and soft start and configurable duty cycle limit.

According to Toth, this part is now released to production and received DLA qualifications in Q1 of this year. It's also now available in eight models: four in hermetic packages with 100-krad TID ratings as previously announced and four more rad-tolerant versions in plastic packages with TID ratings up to 50 krad and SEE ratings up to 43 MeV/mg/cm^2.

The rad-hard hermetic models carry the TPS7H5001-SP, '5002-SP, '5003-SP and '5004-SP part numbers while the plastic-packaged models carry the TPS7H5005-SEP, '5006-SEP, '5007-SEP, and '5008-SEP part numbers. In these two package categories, the differences among the models relate to the number of outputs, and programming of deadtime and blanking, and duty cycle limits as shown in the table below.

Table. TPS7H500x-SP device comparisons.

Device	Primary outputs	Synchronous rectifier outputs	Dead time setting	Leading edge blank time setting	Duty cycle limit options
TPS7H5001-SP	2	2	Resistor programmable	Resistor programmable	50%, 75%, 100%
TPS7H5002-SP	1	1	Resistor programmable	Resistor programmable	75%, 100%
TPS7H5003-SP	1	1	Fixed (50-ns typ.)	Fixed (50-ns typ.)	75%, 100%
TPS7H5004-SP	2	0	Not applicable	Resistor programmable	50%
TPS7H5005-SEP	2	2	Resistor programmable	Resistor programmable	50%, 75%, 100%
TPS7H5006-SEP	1	1	Resistor programmable	Resistor programmable	75%, 100%
TPS7H5007-SEP	1	1	Fixed (50-ns typ.)	Fixed (50-ns typ.)	75%, 100%
TPS7H5008-SEP	2	0	Not applicable	Resistor programmable	50%

TI gave a presentation on this controller at APEC in which they discussed designing and simulating with this controller in Simplis. Another new development within the space parts group at TI is that it is offering SIMPLIS models for all the space power parts. In the past, the company only offered Spice models.

And while on the subject of plastic-packaged space parts, Toth commented that an addition to MIL-PRF-38535 covering plastic encapsulated microcircuits (PEMs), QML Class P is coming. The JEDEC working group on space parts has made the revision available for comment with the goal of having it ratified it by the end of the year.

TI also displayed a demo board for the TPS7H4010 SEP, a 6-A 30-V input POL in space-enhanced plastic. This part was also discussed at NSREC 2021 and had been released the November prior to that and introduced publicly at NSREC 2020. Mark commented that this is the only POL in space grade that can handle up to 32 V, making it suitable for 28-V bus applications.

Apogee Semiconductor provided an update on the status of its AFP1422 rad-hard PWM controller IC currently in development with NASA's Space Technology Mission Directorate—they now have silicon. This milestone was delayed by the fab slowdown that occurred during the Covid pandemic. According to the company, this PWM controller is the only PWM part that is both rad hard and uses digital control. The company is currently developing two reference designs for this PWM controller chip—a buck/flyback converter and phase-shifted half bridge.

That digital approach is not surprising given that, aside from this controller, Apogee's efforts to date have mainly been focused on developing rad-hard logic functions and custom logic chips. According to Apogee, their products offer an alternative to much older logic parts that are not rad hard by design, but rather upscreened, and for which radiation assurance data may not be available.

At the NSREC expo, Apogee highlighted their RadFlex semi-custom logic chips, which enable the company to develop logic devices from its rad-hard assured silicon substrates. These chips leverage the company's "sea of gates" design structure and preorganized I/O and power, such that logic functions are implemented at the final metal layer, allowing the creation of a single custom mask to implement the needed logic function. This approach has several advantages including cost reduction versus up-screening; fast delivery: three months for EM parts; six months for flight-ready parts; and most standard or custom logic functions can be implemented.

The company has already used its "sea of gates" design structure to produce a number of standard logic functions ranging from simple NAND and NOR gates up to a rad hard voter, level translators and a transceiver, which have been discussed at previous NSRECs.

Other Updates

Simon Abel, director, Business Development, Strategic Accounts at Crane Aerospace & Electronics provided an update on the previously introduced SMP12005S space dc-dc converter with 80-V to 160-V input. He noted that this converter is going through qualifications and that a class K version is coming later this year.

In November of last year, CAES introduced the SCD51028xx series of dc-dc converters that step down 28-V input to point-of-load voltages in a single stage and with power ratings from 50 to 75 W. The company described these converters as the first single-stage, isolated dc-dc converters for high-throughput satellite payloads.

They note that the CAES single-stage converters increase power efficiency from approximately 80% to more than 90% while simultaneously reducing size, weight and power requirements in space applications. The SCD51028xx converters are available in a 2.5- (l) x 1.5- (w) x 0.63- (h) inch gull-winged power package. This performance is achieved using GaN FETs and these converters have a total dose radiation tolerance of 50 krads (Si). The company has been showing the SCD51028xx this year at various conferences including NSREC.

At the Analog Devices' booth, Eamon Nash, applications engineering director, Aerospace, Defense and RF Products Business Unit, offered some details on new space power products. He noted the recently released RH3845MW dc-dc controller and two linear regulators that are currently in development—the ADLT3045S, a 20-V, 500-mA ultra-low-noise and ultra-high PSRR linear regulator and the RH3080, a 1.2-V to 36-V, 0.9-A LDO with single-resistor setting of output voltage.

The RH3845MW dc-dc controller is a synchronous stepdown controller in a 16-pin flatpack. Operating from a 4-V to 60-V input (with 7.5 V minimum at startup), the controller produces output voltages up to 36 V at currents up to 10 A with 1.5% output regulation accuracy. Typical efficiency is 94% at 30-V input, and 15-V, 3-A output.

Switching frequency is adjustable from 100 to 500 kHz and two versions are offered—one with pulse skipping mode and one with forced continuous mode. It can be ordered as a standalone controller or as a kit with FETs. Radiation specs include no low dose rate sensitivity up to 100 kRad (Si) TID and an SEL threshold LET ≥117.6 MeV.cm^2/mg at T_{CASE} = 100°C (<30-V input).

At 3D Plus' exhibit, Richard Sutton reported that the company is introducing a new POL. The 3DPM0349 is a regulator with 3-V to 6-V input and 0.8- to 3.3-V output at a high current of 7 A. Additionally it can be cascaded for even higher current. The release of this product is expected in September or October.

STMicroelectronics showed an eval board for the RHRPMICL1A integrated current limiter, which it demonstrated at NSREC 2019.[1] And while it wasn't shown at NSREC, another device—the LEO3910, a rad-hard plastic 2-A positive low dropout regulator—was released by STMicroelectronics around the time of the conference.

Last year, Microchip introduced its SA50-120 family of rad-hard, isolated dc-dc converters, which utilize surface-mount components on pc boards rather than hybrid construction. The members of this family deliver up to 56 W of output in a small, low-profile solution while operating from a 120-V bus. Units are available with single outputs of 3.3 to 28 V, or with a 3.3-V or 5-V main output and 12-V or 15-V auxiliary outputs. The units are qualified to 100 krad (Si) TID and SEE greater than 80 MeV·cm^2/mg.

At this year's NSREC, Jim LeClare, Microchip's Aerospace and Defense marketing manager, HiRel Products, reported that the company followed that development by introducing a rad-tolerant version with 28-V input in January of this year. This SA50-28 product line is a 20-V- to 40V-input, 50-W family with nine standard outputs of 3.3 V, 5 V, 12 V, 15 V and 28 V in single- and triple-output configurations.

As was the case with the SA50-120, the company touted its unique use of non-hybrid assembly in the SA50-28, describing it as the industry's only off-the-shelf, 28-V-input, radiation-tolerant power converter based on discrete components with surface-mount construction and non-hybrid assembly processes. These alternatives to hybrid-style converters are said to improve design flexibility while reducing system size, cost, and development time.

More recently the SA50-28 family has been expanded to provide radiation hardened models with TID > 100 krad(Si) and 30-krad(Si) ELDRS, and SEE immunity of 82 MeV·cm^2/mg. Datasheets for these models are available on the company's website.

Beyond the power converter products, the company is also developing its power semiconductor and IC products. For example, LeClare noted that the company plans to reintroduce a space-grade version of the SG1843 PWM controller and will offer an eval board for this device.

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For more on news about rad-hard and rad-tolerant power components and power converters, see How2Power.com's Space Power section.